National Aeronautics and Space Administration

NASAfacts

Inflatable Re-entry Vehicle Experiment

"A WIND TUNNEL IN THE SKY"

NASA's Inflatable Re-entry Vehicle Experiment, or IRVE, is a mission designed to demonstrate that an inflatable structure can be used as a heat shield to safely slow a spacecraft moving at hypersonic speed (greater than Mach 5, or five times the speed of sound) through a planet's atmosphere. This technology could be used on a future mission to land a spacecraft on Mars.

The purpose of a heat shield is to prevent a spacecraft from being damaged by high temperatures as it decelerates through a planet's atmosphere. The larger the total surface area of the heat shield, greater the drag force generated. This increased drag can be used to deliver more mass to a given altitude or surface elevation, or a given mass to a higher altitude or surface elevation. The larger heat shield produces more friction at higher altitudes, slowing the spacecraft down faster in thinner atmospheres. The ability to land a probe at a higher surface elevation will open up more of a planet's surface to exploration.

Currently, the size of the rigid heat shield available for any given mission is limited by the diameter of the launch vehicle's payload fairing, which in turn limits the payload size and weight, the number of science instruments that can be carried, and the resulting productivity of the mission. An inflatable heat shield would not be constrained by the fairing diameter and would allow a larger, more capable payload to be flown.

IRVE will demonstrate with a subscale model that a vehicle entering a planet's atmosphere – in this case, Earth's – can inflate a

NASA engineers check out the Inflatable Re-entry Vehicle Experiment in the lab. *Image credit: NASA/Sean Smith* heat shield and withstand the temperatures and pressures characteristic to hypersonic velocities. Computer models, wind tunnel tests and engineering assessments have provided every indication IRVE will work. But the concept will not be proven until the experiment actually flies, taking advantage of what NASA researchers describe as “a wind tunnel in the sky.”

RE-ENTRY VEHICLE AND MISSION DESCRIPTION

The 1,400 pound IRVE inflatable re-entry vehicle will begin its mission packed into a single column stowed within the 22-inch diameter nose cone of a Black Brant 9 rocket. The inflatable fabric surrounds a central instrument core like a folded umbrella. The center body structure has two parts—a forward segment where the instrumentation is located and an aft segment that holds the inflation system.

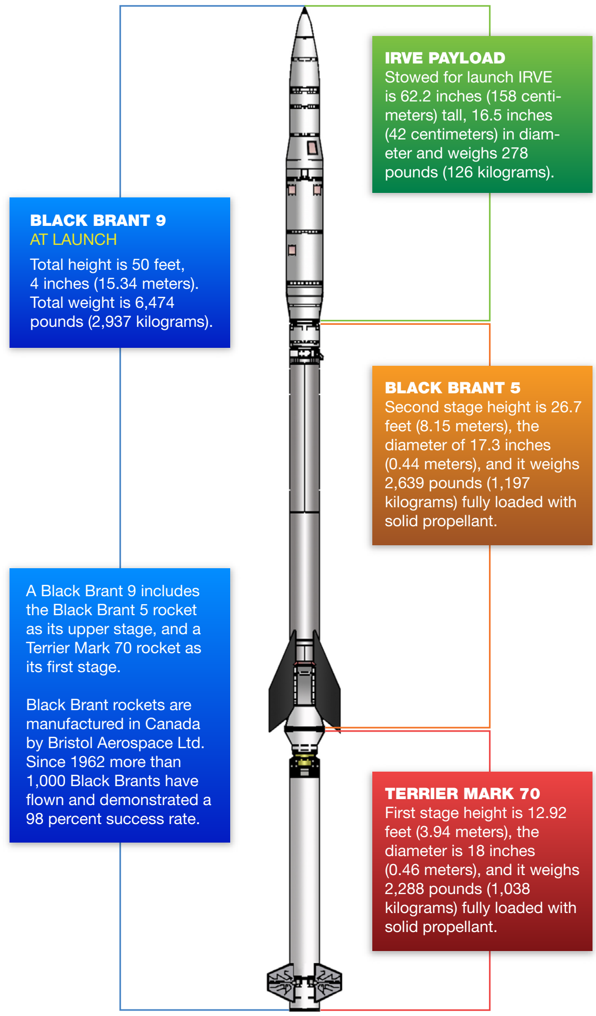
The inflatable aeroshell holds its nitrogen gas inside bladders made of Kevlar fibers coated with silicone. The Kevlar gives the bladder its structure, while the silicone enables it to hold pressure. The bladders are covered with three layers of Kevlar for added support, three layers of Kapton film, and three layers of open-weave Nextel fabric, which is the front line defense against the re-entry heat.

The instrument core holds six video cameras, with five spaced apart in a circle at one level and one positioned slightly below the others. Each camera has a 72-degree field of view and will be used to observe the inflation and behavior of the heat shield during atmospheric re-entry. The video and other data will be sent to a receiving station on the ground and recorded for later analysis. No information will be recorded on board IRVE because the experiment will not be recovered.

After launch from NASA’s Wallops Flight Facility in Virginia and a four-minute climb to 131 miles over the Atlantic Ocean, the re-entry vehicle will begin its descent. An inflation system similar to the air tanks used by scuba divers will begin to inflate the 10-foot-diameter aeroshell with inert nitrogen gas and the onboard cameras will begin recording the view from space.

Instruments in the heat shield will provide temperature and pressure data, while an onboard transponder will help ground-based radars lock on to the re-entry vehicle and track its position as it descends.

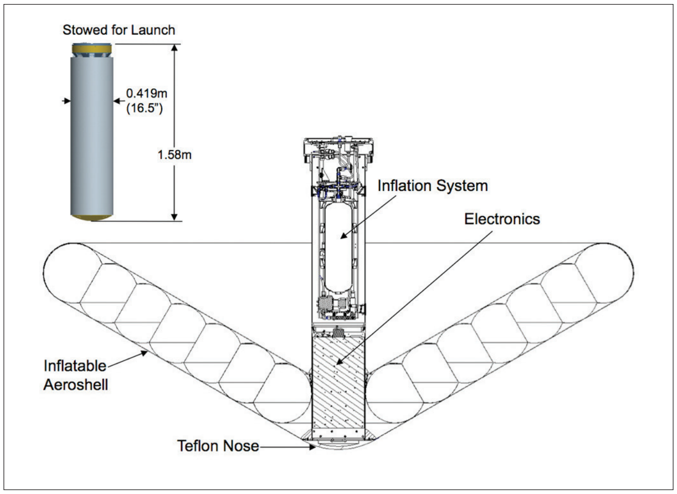
There are no other deceleration devices on the vehicle. Once IRVE has passed through the heat pulse, slowed to supersonic (between Mach 1 and Mach 5) and then subsonic speeds (less than Mach 1), it will splash down in the Atlantic Ocean about 20 minutes after launch and 100 miles down range from Wallops.



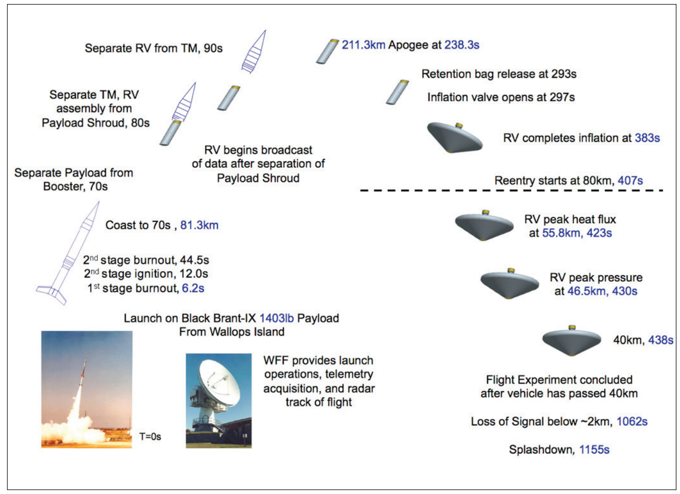
A Black Brant 9 rocket will lift the Inflatable Re-entry Vehicle Experiment to an altitude of about 130 miles above Earth. *Image credit: NASA*

MISSION MILESTONES (MINUTES: SECONDS)

00:00	Launch from Wallops Flight Facility.
00:06	Terrier first stage burns out.
00:12	Black Brant second stage ignites.
00:45	Black Brant second stage burns out.
01:20	Payload shroud separates from nose cone.
01:30	IRVE separates from nose cone.
03:58	IRVE reaches its highest point, 131 miles.
04:57	Valve opens to begin inflating the heat shield.
05:32	Heat shield is fully inflated.
06:47	Re-entry vehicle descends through 50 miles and begins interacting with the atmosphere.
07:03	Re-entry vehicle experiences peak heating at 35 miles.



The Inflatable Re-Entry Vehicle consists of an aeroshell, an inflation system and an instrument core containing electronics. It is designed to re-enter with its Teflon nose facing forward.



From launch to splashdown, the IRVE mission will last about 19 minutes.

07:10 Re-entry vehicle reaches maximum dynamic pressure or drag force, at 29 miles.
07:18 Flight experiment concludes as re-entry vehicle descends through 25 miles.
17:27 Loss of signal as the re-entry vehicle falls below 1.2 miles altitude.
18:57 Re-entry vehicle impacts ocean 100 miles downrange and sinks.

MISSION SUCCESS CRITERIA

The IRVE mission team has three primary goals whose achievement will be the minimum requirement for success.

1. The re-entry vehicle deploys from the launch vehicle without re-contacting the rocket's second stage, nose cone or shroud.
2. IRVE's nitrogen gas system inflates the re-entry vehicle to the desired conical shape.
3. Ground-based radar systems track the inflated re-entry vehicle sufficiently to evaluate the hardware's drag performance through the atmosphere.

In addition to the minimum success criteria, project scientists have identified five more comprehensive mission objectives.

1. The re-entry vehicle inflates to its desired conical shape before experiencing heat levels that come within 10 percent of the maximum predicted heating.
2. The re-entry vehicle maintains structural integrity and inflation through peak heating and peak dynamic pressure.
3. Data on the re-entry vehicle's attitude, flight path, thermal performance and bladder pressure – along with video signals – are successfully transmitted to the ground and recorded during the period from launch through peak heating and peak dynamic pressure.
4. The launch vehicle deploys the re-entry vehicle without causing it to tumble, and so that the side of the heat shield with a convex shape and a point at the center faces forward for re-entry.
5. The re-entry vehicle orients itself prior to re-entry to an angle of attack no less than 35 degrees from vertical and maintains that angle of attach though peak heating and dynamic pressure.

LAUNCH SITE

NASA's Wallops Flight Facility is located on Virginia's Eastern Shore on the Delmarva Peninsula approximately 80 miles northeast of Norfolk, Va., and 40 miles southeast of Salisbury, Md. Covering an area of 6,000 acres, Wallops consists of three separate properties: the Main Base, the Wallops Mainland and the Wallops Island Launch Site.

Managed by NASA's Goddard Space Flight Center in Greenbelt, Md., Wallops was established in 1945 by the National Advisory Committee for Aeronautics as a center for aeronautical research and is one of the oldest launch sites in the world. Wallops hosted its first launch on July 4, 1945 and since then more than 16,000 rockets have launched from the Virginia coast.

IRVE will launch from Wallops' Pad 2, one of six designated launch areas on Wallops Island. The pad includes a 45-foot-long rail that can support rockets up to 20,000 pounds and may be pointed in a wide range of directions to support a wide variety of sounding rocket missions. A moveable environmental shelter at the pad facilitates all-weather access to the rocket when it is loaded on the rail, as well as protects the rocket and its payload from inclement conditions.

LAUNCH VEHICLE

The IRVE payload will be launched atop a two-stage Black Brant 9 rocket provided by NASA's Wallops Flight Facility. The first stage consists of a solid-fueled Terrier Mark 70 rocket that is 14.1 feet long, has a diameter of 18 inches and weighs 2,288 pounds fully loaded with solid propellant. The second stage is a Black Brant 5 rocket that is 18.6 feet long, has a diameter of 17.3 inches and weighs 2,639 pounds fully loaded with solid propellant.

The Black Brant 9 uses a 45-foot-long rail to provide its initial guidance. Four fins on the Terrier Mark 70 first stage and four fins on the Black Brant 5 second stage provide stability for the vehicle as it flies a ballistic trajectory. The rocket is capable of carrying between 1,000 and 1,500 pounds of payload, reach a top altitude of between 102 and 153 miles, and expose the payload to no more than 11 g during launch and 9.9 g during entry.

Black Brant sounding rockets are manufactured by Bristol Aerospace Limited of Canada. Since 1962, more than 1,000 Black Brants have been launched around the world with a 98 percent success rate.

COUNTDOWN

The countdown will begin four-and-a-half hours before the opening of the launch window. Participants will be called to their stations and must be ready to support launch three-and-a-half hours before the opening of the launch window. During this time final checks of the Black Brant 9 and the IRVE payload will be made, a series of smaller rockets will be launched a few thousand feet into the air to test radar tracking systems, and the range will be checked for any air or boat traffic straying too close to the launch and impact hazard zones.

Also during this time weather officials will brief the launch team on current and forecast conditions, which will be used to determine precisely which direction the rail-mounted rocket should be pointed. The launcher then will be elevated to the proper angle and the launch vehicle armed.

Forty minutes before the IRVE launch, a sounding rocket will be sent into the upper atmosphere and release an inflatable sphere, which will be tracked by radar to gather meteorological data that will be necessary to help IRVE project scientists analyze the results of the mission after the flight.

The terminal countdown begins eight minutes before launch. Engineers will remotely activate the IRVE payload, and three minutes before launch switch the rocket and payload to internal power. At the moment the clock reaches zero the solid motor on the first stage Terrier rocket will be ignited and the IRVE mission will fly from the rail to begin the 20-minute mission.

MISSION CREDITS

NASA's Fundamental Aeronautics Program, part of the agency's Aeronautics Research Mission Directorate in Washington, is responsible for all hypersonic research through the atmosphere, whether that atmosphere surrounds Earth, Mars or another planet. Jaiwon Shin is NASA's associate administrator for aeronautics research. James Pittman is the principal investigator for the Hypersonics Project within the Fundamental Aeronautics Program.

NASA's Langley Research Center in Hampton, Va., is the lead center for the IRVE mission. The center director is Lesa B. Roe. The mission project manager is Mary Beth Wusk. The hypersonics project scientist and principal investigator for the mission is Neil Cheatwood. NASA's Wallops Flight Facility is the launch site, where the range project manager is Jack Vieira and Jay Scott is the vehicle mission manager. ILC Dover of Delaware built the inflatable aeroshell, while Bristol Aerospace Limited of Canada manufactured the launch vehicle.

For more information about NASA's aeronautics research programs contact Beth Dickey at 202-358-2087 or *beth.dickey-1@nasa.gov*. For more information about IRVE contact Kathy Barnstorff at 757-864-9886 or *kathy.barnstorff@nasa.gov*. For more information about the launch vehicle and Wallops range operations contact Keith Koehler at 757-824-1579 or *keith.a.koehler@nasa.gov*.

National Aeronautics and Space Administration

Headquarters
300 E. Street, SW
Washington, DC 20546

www.nasa.gov